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NATIONAL DAM SAFETY PROGRAM. CAMERON RESERVOIR NUMBER 2 DAM (MO--ETC(U)
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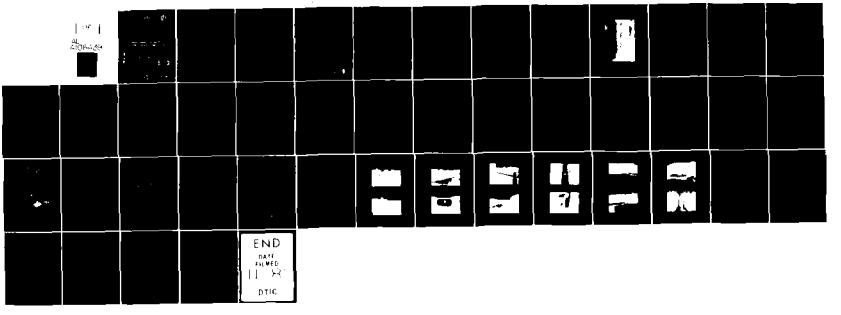

LEVEL II

1

GRAND-CHARITON BASIN

AD A106439

CAMERON RESERVOIR NO. 2 DAM

DEKALB COUNTY, MISSOURI

MO 10169

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

JULY 1979

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REPORT DOCUMENTATION PAGE

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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CAMERON RESERVOIR NO. 2 DAM

DEKALB COUNTY, MISSOURI

MO 10169

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

JULY 1979

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Cameron Reservoir No. 2 Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Cameron Reservoir No. 2 Dam:

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1. Spillway will not pass 50 percent of the Probable Maximum Flood.
2. Overtopping could result in failure of the dam.
3. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED
Chief, Engineering Division — 4 JAN [illegible]
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer — 4 JAN 19[illegible]
Date

CAMERON RESERVOIR NO. 2 DAM

DE KALB COUNTY, MISSOURI

MISSOURI INVENTORY NO. 10169

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

JULY 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Cameron Reservoir No. 2 Dam
State Located	Missouri
County Located	De Kalb County
Stream	Tributary to Grindstone Creek
Date of Inspection	3 July 1979

Cameron Reservoir No. 2 Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as an intermediate size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten the Cameron Reservoir, four houses, and two county roads, within the estimated damage zone which extends approximately four miles downstream of the dam.

Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will pass neither 50 nor 100 percent of the probable maximum flood without overtopping but will pass 20 percent of the probable maximum flood. The spillway will not pass the 100-year flood but will pass the 10-year flood. The spillway design flood recommended by the guidelines is the probable maximum flood. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Deficiencies visually observed by the inspection team were minor seepage at the left retaining wall in the spillway, presence of excessive brush and trees on the embankment, erosion of two vehicular tracks on the downstream embankment face, minor cracking of the discharge channel slab, erosion of material behind the left spillway retaining wall, and deterioration of the right spillway retaining wall. Seepage and stability analyses required by the guidelines were not available.

There were no deficiencies or conditions existing at the time of the inspection which raised questions concerning the safety of this structure. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.

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Harry L. Callahan

Harry L. Callahan, Partner
Black & Veatch

OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CAMERON RESERVOIR NO. 2 DAM

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Cameron Reservoir No. 2 Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The Cameron Reservoir No. 2 Dam is an earth structure located in a tributary valley to Grindstone Creek in southeastern De Kalb County, Missouri (Plate 1). The upstream slope is protected with randomly sized riprap from the water surface to near the embankment crest and is laden with small trees and excessive brush. Brush, small trees, and grass protect the downstream slope although several vehicle paths extend from crest to toe. The crest is characterized by a grass covered vehicle path. There is no internal drainage system in the embankment.

(2) A concrete broad-crested weir 75 feet in length is constructed at the left abutment and serves as the spillway. The spillway has a flat crest which is 2.7 feet wide. Discharge over the weir proceeds down the concrete spillway discharge channel to Cameron Reservoir near the toe of the embankment.

(3) A water supply intake is located immediately upstream of the embankment. According to available design drawings, a concrete encased 12-inch water supply pipe runs beneath the embankment to water supply pumping station downstream of Cameron Reservoir No. 1.

(4) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in southeastern De Kalb County, Missouri, as indicated on Plate 1. The lake formed by the dam is located on the United States Geological Survey 15 minute series quadrangle map for Maysville, Missouri in Section 10 of T57N, R30W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the intermediate size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Cameron Reservoir No. 2 Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Cameron Reservoir No. 2 Dam the estimated flood damage zone extends downstream for approximately four miles. Within the damage zone are four homes and Cameron Reservoir.

e. Ownership. The dam is owned by the City of Cameron, Missouri, 205 N. Main, Cameron, Missouri 64429.

f. Purpose of Dam. The dam forms a 30-acre water supply and recreational lake.

g. Design and Construction History. Design drawings were available from Black & Veatch, Consulting Engineers, Kansas City, Missouri and indicated that construction of the dam began in about 1936.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation, water supply withdrawals, and the spillway capacity all combine to maintain a relatively stable water surface elevation.

1.3 PERTINENT DATA

a. Drainage Area - 1,158 acres.

b. Discharge at Damsite.

(1) Discharge at the damsite is presently through an ungated, concrete control sill acting as a broad-crested weir at the left abutment of the dam.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation - 5,424 cfs (Probable Maximum Flood Pool El.950.6).

c. Elevation (Feet Above M.S.L.).

(1) Top of dam - 946.5 ± (see Plate 3)

(2) Spillway crest - 942.8

(3) Streambed at toe of dam - 905.0 ±

(4) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 3,500 feet ±

(2) Length of normal pool - 3,000 feet ±

e. Storage (Acre-feet).

(1) Top of dam - 387

(2) Spillway crest - 249

(3) Design surcharge - Not available.

f. Reservoir Surface (Acres).

(1) Top of dam - 46

(2) Spillway crest - 30

g. Dam.

(1) Type - Earth embankment

(2) Length - 435 feet

(3) Height - 42 feet ±

(4) Top width - 16 feet ±

(5) Side slopes - A section taken near Station 2+50 of the embankment had an upstream face slope of 1.0 V on 2.8 H and downstream face slope of 1.0 V on 2.0 H above the berm and 1.0 V on 1.5 H below the berm.

(6) Zoning - (see Plate 4).

(7) Impervious core - (see Plate 4).

(8) Cutoff - (see Plate 4).

(9) Grout curtain - Unknown.

(10) Internal drainage system - None.

h. Diversion and Regulating Tunnel - None.

i. Spillway.

(1) Type - Concrete broad-crested weir.

(2) Length of weir - 75 feet.

(3) Crest elevation - 942.8 feet m.s.l.

(4) Gates - None.

(5) Upstream channel - Not applicable.

(6) Downstream channel - The spillway discharges to a concrete channel near the left abutment which, in turn, discharges to Cameron Reservoir.

j. Regulating Outlets - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Limited design data were available in the form of design drawings, construction estimates, and hydrologic computations provided by Black & Veatch Consulting Engineers, Kansas City, Missouri.

2.2 CONSTRUCTION

Construction records were unavailable, however the design file indicates the dam was completed in approximately 1938.

2.3 OPERATION

Procedural criteria for operation of this dam were not available. Documentation of past experiences of a serious nature were unavailable.

2.4 GEOLOGY

The dam is located in a valley formed in shales and limestones of the Bonner Springs Shale and Plattsburg Limestone. These are overlain by the Gosport Variant of the Gosport Series and the Zook silty clay loam varying from 5 to 10 feet. The foundations and abutments of the dam are thought to be shale and limestone overlain by silty clay. The bedding in the rock structure is horizontal and medium to thin with closed bedding planes and a few, vertical widely spaced joints.

2.5 EVALUATION

a. Availability. Limited engineering data was obtained as noted in 2.1.

b. Adequacy. No engineering data were available upon which to make a detailed assessment of the design, construction, and operation. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions and made a matter of record.

c. Validity. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Cameron Reservoir No. 2 Dam was made on 3 July 1979. The inspection team included professional engineers with experience in dam design and construction, hydrology, hydraulic engineering, and geotechnical engineering. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following items at the dam. Evidence of seepage was observed downstream of the spillway at the left retaining wall of the discharge channel. Flow of less than 1 gpm was observed in this area at the time of inspection. Slope protection on the upstream face consists of randomly graded riprap, brush, and small trees. The 12-inch riprap slope paving which was identified on the design drawings was not observed. The downstream face is protected with a vegetal cover with many trees of less than 4 inches in diameter. The inspection team observed no evidence that the embankment had been overtopped. Vehicle tracks were observed at several locations along the downstream embankment face and extended from the crest to the downstream toe. No toe drains or relief wells were observed at the embankment during the visual inspection nor found in the review of the design drawings. No obvious settlement, sinkholes, potholes, cracking, sliding, nor animal burrows were observed. Visual identification and probing indicated the embankment is constructed of silty clay material.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The spillway consists of a concrete control sill which appears in generally good condition. Drain pipe outlets protrude from the slab in the spillway discharge channel. No flow was observed coming from the pipes which appeared to be open and functioning. The drain pipes serve to relieve pore pressure beneath the concrete slab. The design drawings show that 2-inch steel pipe drains are located below the surface of the downstream side of the spillway. It is unknown whether these drains are operating. No erosion of the spillway or discharge channel has occurred. Erosion of abutment material behind the left spillway retaining wall was observed. Minor cracking of the discharge channel slab 20 to 30 feet downstream of the spillway was observed. Deterioration of the right spillway retaining wall was evident. In summary, the spillway and discharge channel appeared in good condition.

The intake structure is 5-feet square with a crest elevation of approximately 947. Four sluice gates are located at elevations of approximately 912, 920, 927, and 934. The 12-inch water supply pipe discharges from the intake structure at an elevation of approximately

909. The water supply pipe does not have the capability to drawdown the reservoir because there is no existing means to dispose of the water without passing through the pumping station and treatment facilities.

d. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir.

e. Downstream Channel. The spillway discharges to a concrete channel at the left abutment as described in 3.1c. Flow proceeds to Cameron Reservoir.

3.2 EVALUATION

The inspection team observed no visible evidence of embankment stability problems. Several minor deficiencies were observed during the inspection. Although they are not believed to be an immediate safety hazard they do warrant monitoring and control. The area of seepage should be monitored regularly for quality and quantity. Seepage can cause internal erosion creating cavities and underground channels, thereby weakening the embankment. The riprap erosion protection should be upgraded to prevent wave action from eroding the embankment. The growth of small trees and brush could cause deterioration of the embankment. The roots of trees can loosen the embankment material and also can leave voids through which water can pass. Brush on the dam prevents inspection of the embankment and kills the smaller grasses whose roots are more effective in protecting the surface soil of the slope from erosion. No observation nor evaluation was made of the water supply intake upstream of the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, transpiration, water supply withdrawals, and capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

Maintenance of the embankment and appurtenances is the responsibility of the City of Cameron. The inspection team is unaware of any maintenance program.

4.3 MAINTENANCE OF OPERATING FACILITIES

A water supply intake is located upstream of the dam. Maintenance and operation of the intake is unknown. No inspection of the water supply intake was performed.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing system or preplanned scheme for warning occupants of the hazard zone below this dam.

4.5 EVALUATION

The height of vegetal cover, presence of trees, and eroded vehicle tracks on the embankment are indicative that more frequent maintenance of the dam and appurtenances is in order. Periodic inspection and maintenance of these items should be initiated.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Limited design data pertaining to hydrology and hydraulics were provided by Black & Veatch Consulting Engineers, Kansas City, Missouri.

b. Experience Data. The drainage area and lake surface area are developed from USGS Maysville, Plattsburg, Winston, and Polo, Missouri Quadrangle Maps. The spillway and dam layouts are from surveys made during the inspection and excerpts from the design drawings.

c. Visual Observations.

(1) The spillway is located at the left abutment and is in generally good condition. The training and retaining walls of the spillway are in good condition with the exception of minor seepage at the base of the left retaining wall/spillway interface.

(2) The spillway discharge channel is concrete lined with rock and concrete retaining walls. Discharges over the spillway should not be affected by backwater effects in the discharge channel. The tailwater elevation at the time of inspection was at El.909.4. The maximum tailwater elevation would be approximately El.921.9 under probable maximum storm conditions.

(3) Cameron Reservoir is located immediately downstream and receives all discharges over the spillway and embankment.

d. Overtopping Potential. The spillway will pass neither 50 nor 100 percent of the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway will pass 20 percent of the probable maximum flood. It will not pass the 100-year flood but will pass the 10-year flood without overtopping the dam. The distribution for the 100-year rainfall and for the 10-year rainfall was provided by the St. Louis District, Corps of Engineers. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of intermediate size should pass the probable maximum flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 4,200 cfs of the total discharge from the reservoir of 9,600 cfs. The estimated duration of overtopping is 6.2 hours with a maximum depth of 4.1 feet over the dam. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 700 cfs of the total discharge of the reservoir of 4,300 cfs. The estimated duration of overtopping is 3.7 hours with a

maximum depth of 2.3 feet over the dam. Although evidence of overtopping of the embankment was not visible, soils typical of the embankment surfaces tend to erode in the absence of proper cover. Should the embankment be subjected to prolonged overtopping it is believed that the subsequent erosion could lead to failure.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately four miles downstream of the dam. The inspection team observed the Cameron Reservoir, four houses, and two county roads within the four mile damage zone.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Detailed seepage and stability analysis should be performed as required by the guidelines.

c. Operating Records. No operational records were available.

d. Post Construction Changes. A concrete slab and an under-drain system have been added to the spillway discharge channel subsequent to the original construction indicated on the design drawings. The dates of these post construction additions are unknown.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone.

Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the recent inspection require monitoring and/or control:

(1) Evidence of seepage was observed at the base of the spillway discharge channel retaining wall/spillway interface near the left abutment.

(2) Deterioration of the right retaining wall of spillway discharge channel could lead to erosion of embankment material during large spillway discharges.

(3) Erosion of abutment material was observed behind the left spillway retaining wall.

(4) Brush and small trees are growing on both the upstream and downstream faces of the embankment.

(5) Erosion was observed in vehicular tracks on the downstream face of the embankment.

(6) Minor cracking of the discharge channel slab was observed downstream of the spillway.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the inadequacy of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. It is the opinion of the inspection team that a program should be developed as soon as possible to implement remedial measures recommended in paragraph 7.2b. The item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II. The Phase I investigation raises no serious questions relating to the safety of the dam nor does it identify any serious dangers that would require a Phase II investigation.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment was not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. The spillway has the capacity to pass 20 percent of the probable maximum flood without overtopping the dam. In order to pass the probable maximum flood as required by the Recommended Guidelines, the spillway size and/or height of dam would need to be increased.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended:

(1) Check the downstream face of the dam periodically for seepage and stability problems. If increased seepage flows are observed or sloughing on the downstream embankment slope is noted, the dam should immediately be inspected and the condition evaluated by an engineer experienced in design and construction of earthen dams.

(2) The downstream slope of the embankment should be mowed more frequently and small trees removed. Visual inspection of the embankment could be expedited and more thorough with control of the vegetal cover.

(3) Erosion protection should be improved on the upstream slope and measures taken to prevent further deterioration of the spillway discharge channel retaining walls. These improvements are needed to prevent erosion of the embankment material due to wave action and spillway discharges, respectively.

(4) Measures should be taken to insure that erosion of vehicular paths does not continue. Elimination of vehicle movement on the embankment and establishing proper vegetal cover could preclude further loss of embankment material and reduce the potential for failure.

(5) Appropriate repair measures should be undertaken to repair the cracks in the concrete slab downstream of the spillway.

(6) Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of dams.

(7) A detailed inspection of the dam should be made periodically by an engineer experienced in design and construction of dams.

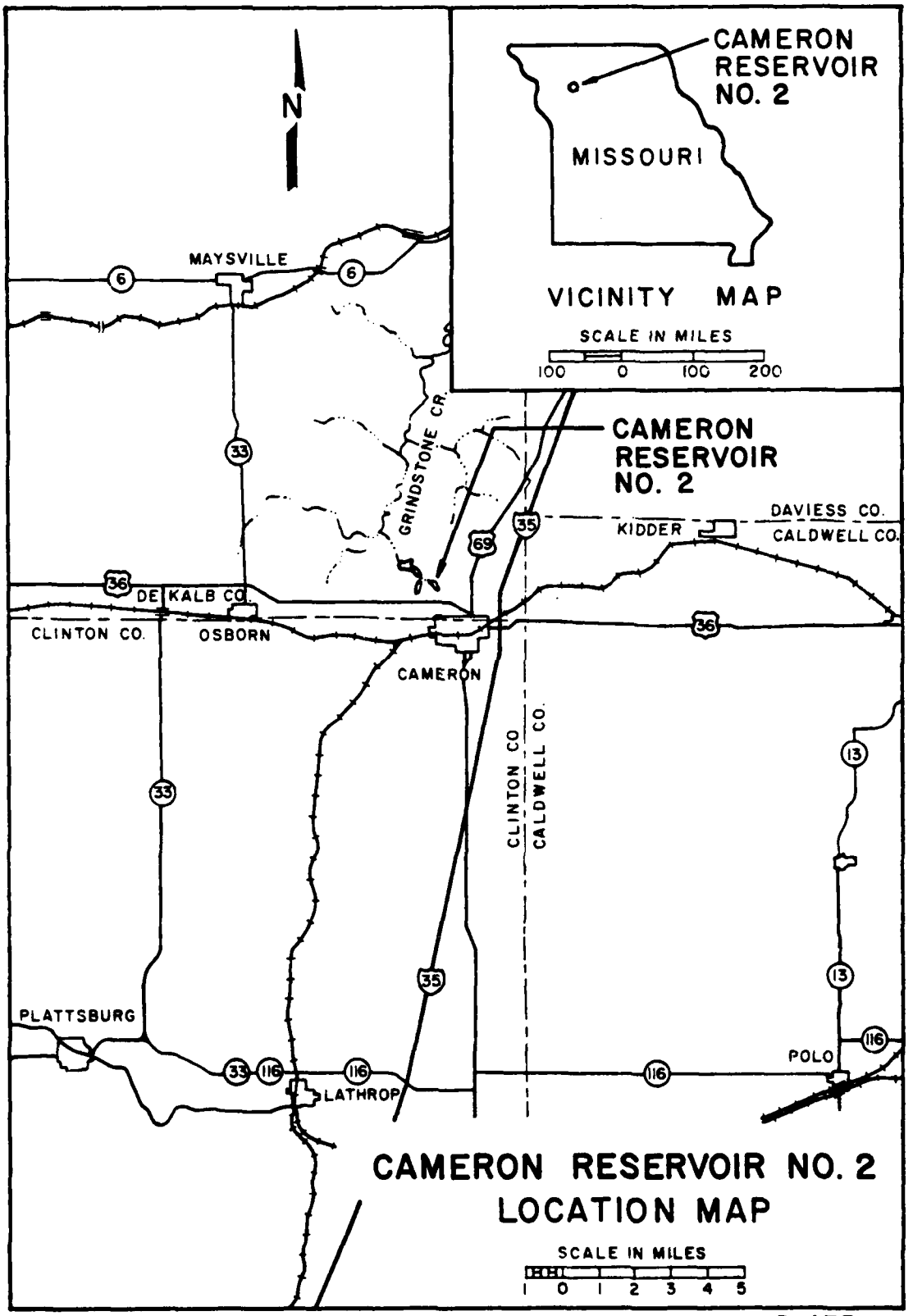

N
CAMERON RESERVOIR NO. 2
MISSOURI
VICINITY MAP
SCALE IN MILES
100 0 100 200
MAYSVILLE
6
6
33
GRINDSTONE CR.
CAMERON RESERVOIR NO. 2
DAVIESS CO.
KIDDER
CALDWELL CO.
35
69
36
DE KALB CO.
CLINTON CO.
OSBORN
CAMERON
36
33
CLINTON CO
CALDWELL CO.
13
13
35
PLATTSBURG
33
116
116
LATHROP
116
POLO
116
CAMERON RESERVOIR NO. 2
LOCATION MAP
SCALE IN MILES
1 0 1 2 3 4 5

PLATE 1

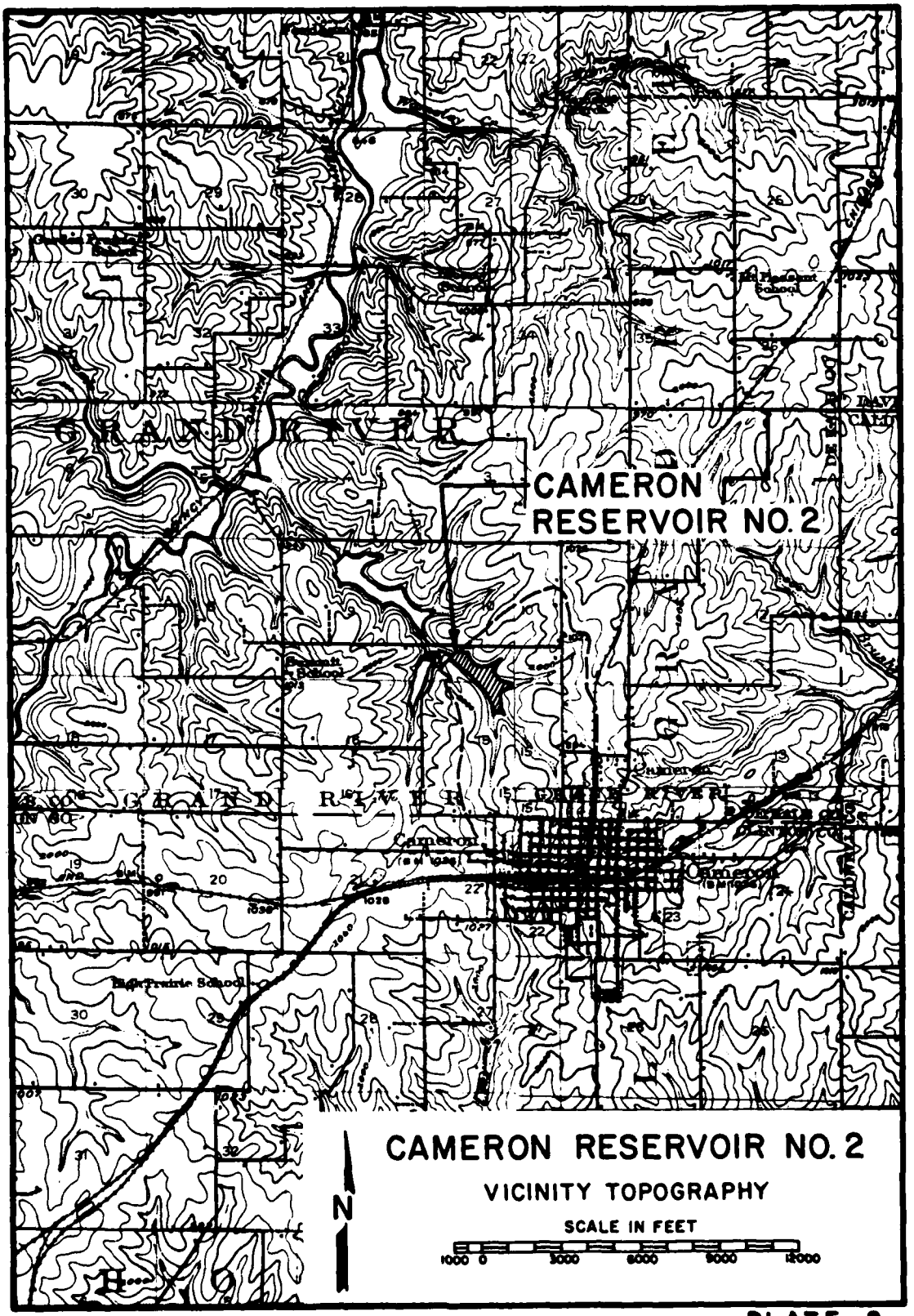
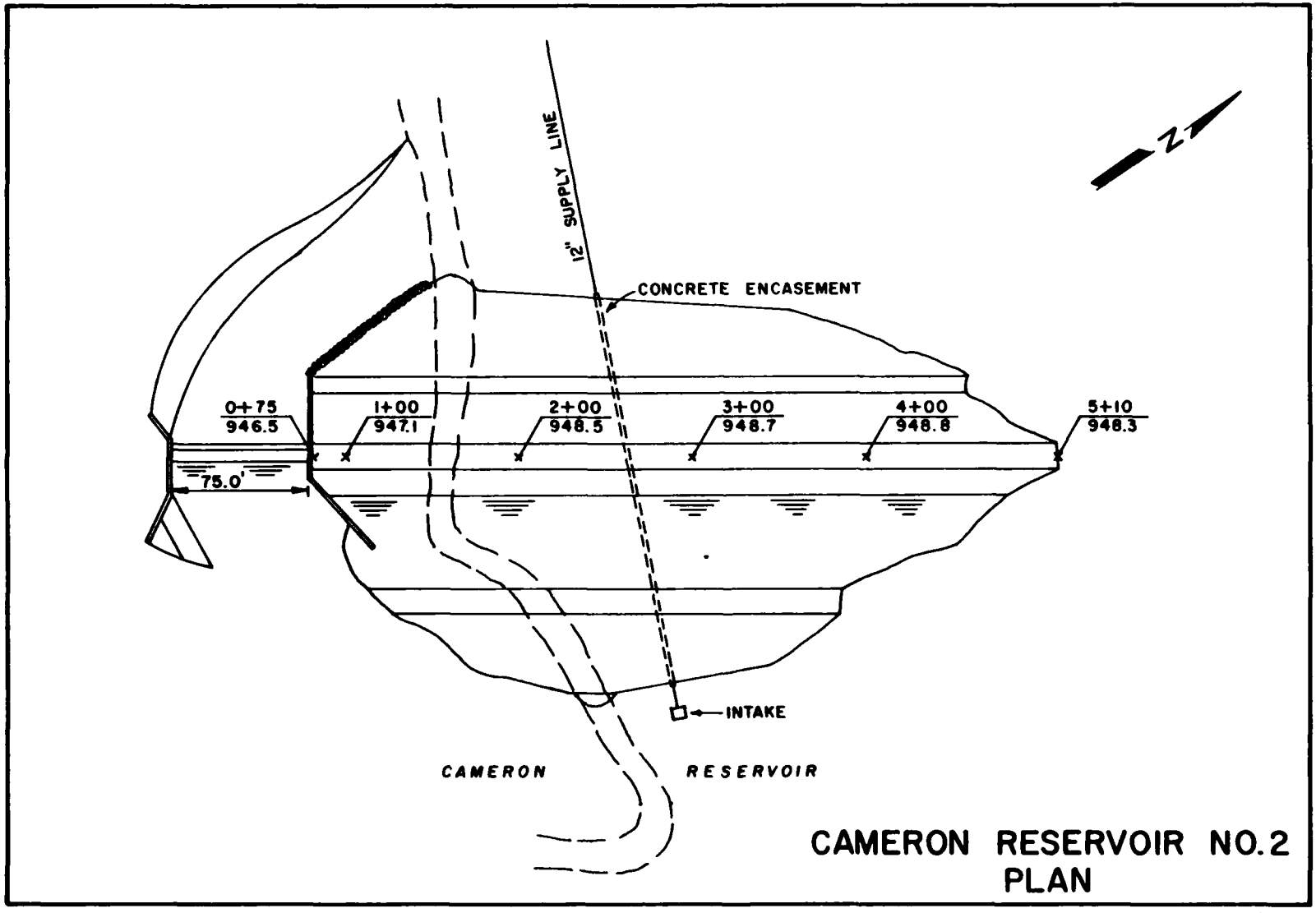
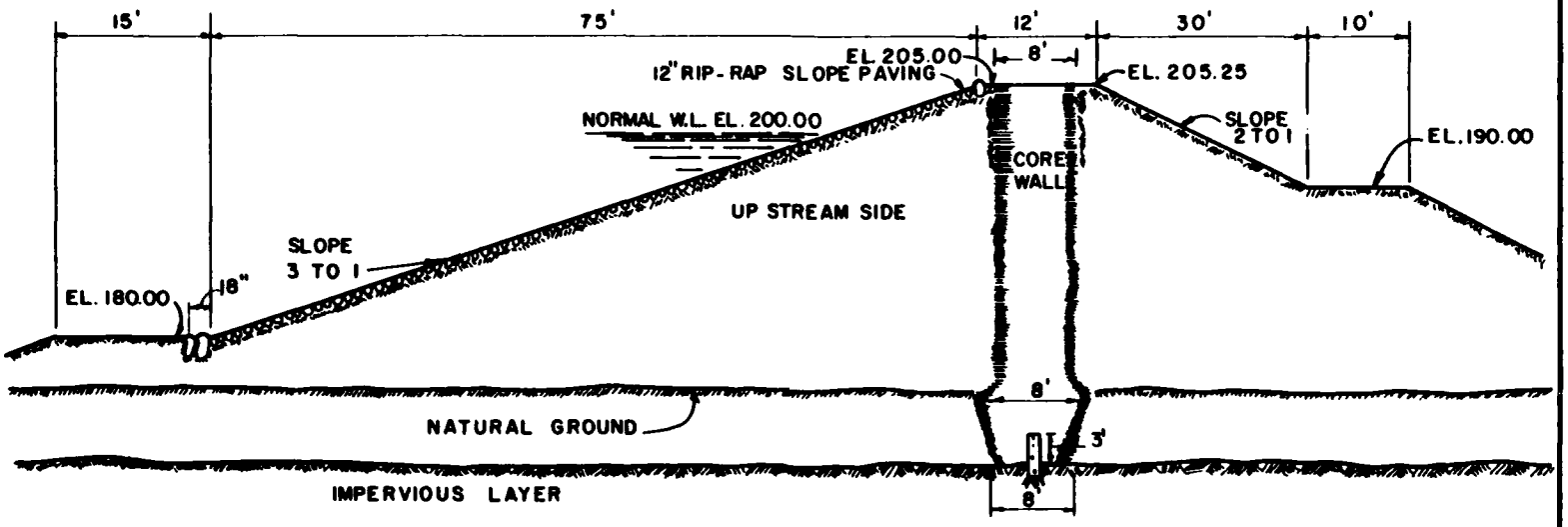

GRAND RIVER
CAMERON
RESERVOIR NO. 2
Cameron
Cameron
Bright Prairie School
N
CAMERON RESERVOIR NO. 2
VICINITY TOPOGRAPHY
SCALE IN FEET
1000 0 3000 6000 9000 12000

PLATE 2



CAMERON RESERVOIR NO.2
PLAN

PLATE 3



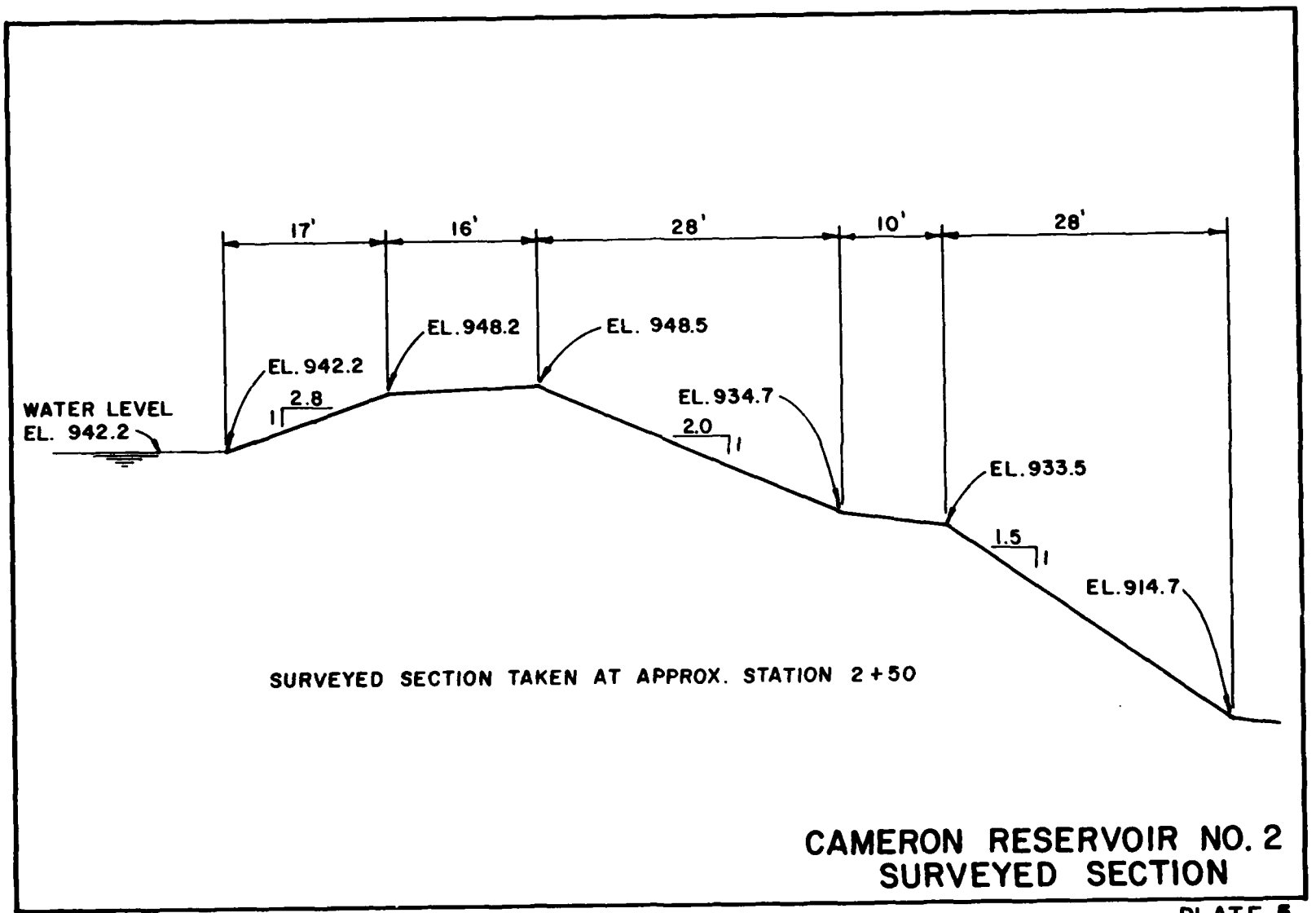
FROM STATION 0+60 TO 4+40

EL. 200 IS APPROXIMATELY EQUAL TO EL 943.3 FEET M.S.L

FROM DESIGN DRAWINGS BY BLACK & VEATCH, 1936 .

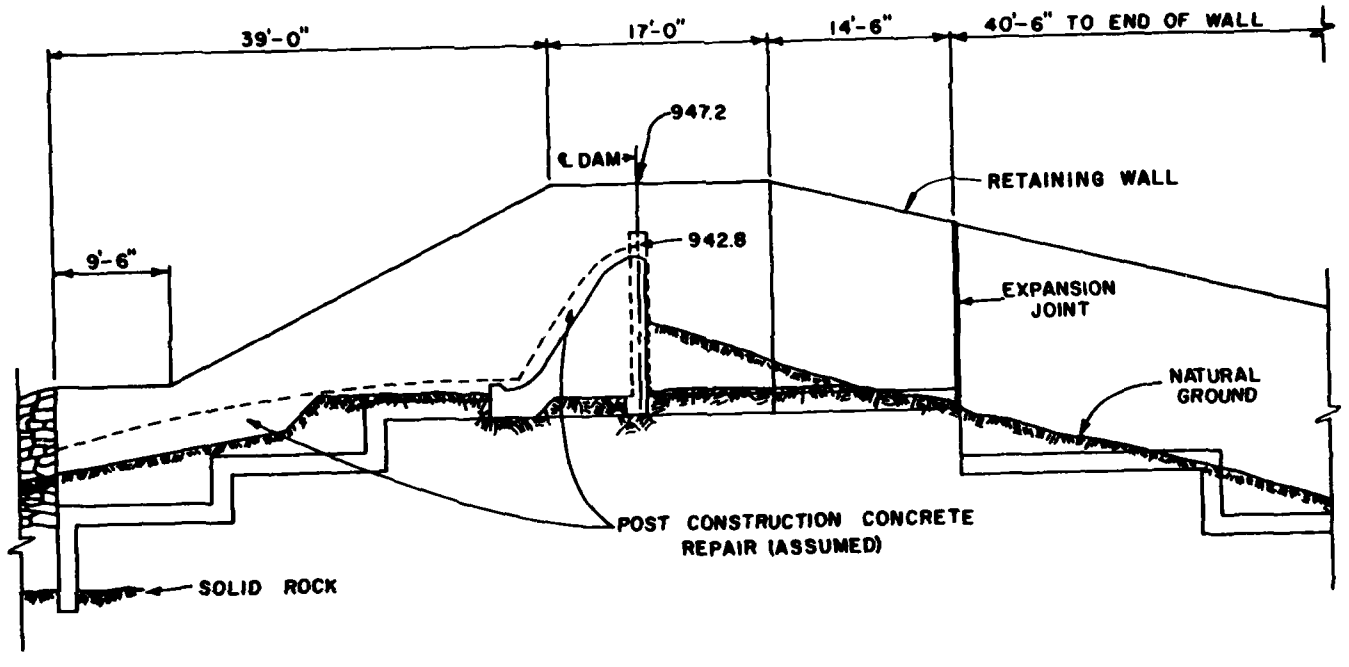
CAMERON RESERVOIR NO. 2
DESIGN SECTION

PLATE 4



CAMERON RESERVOIR NO. 2
SURVEYED SECTION

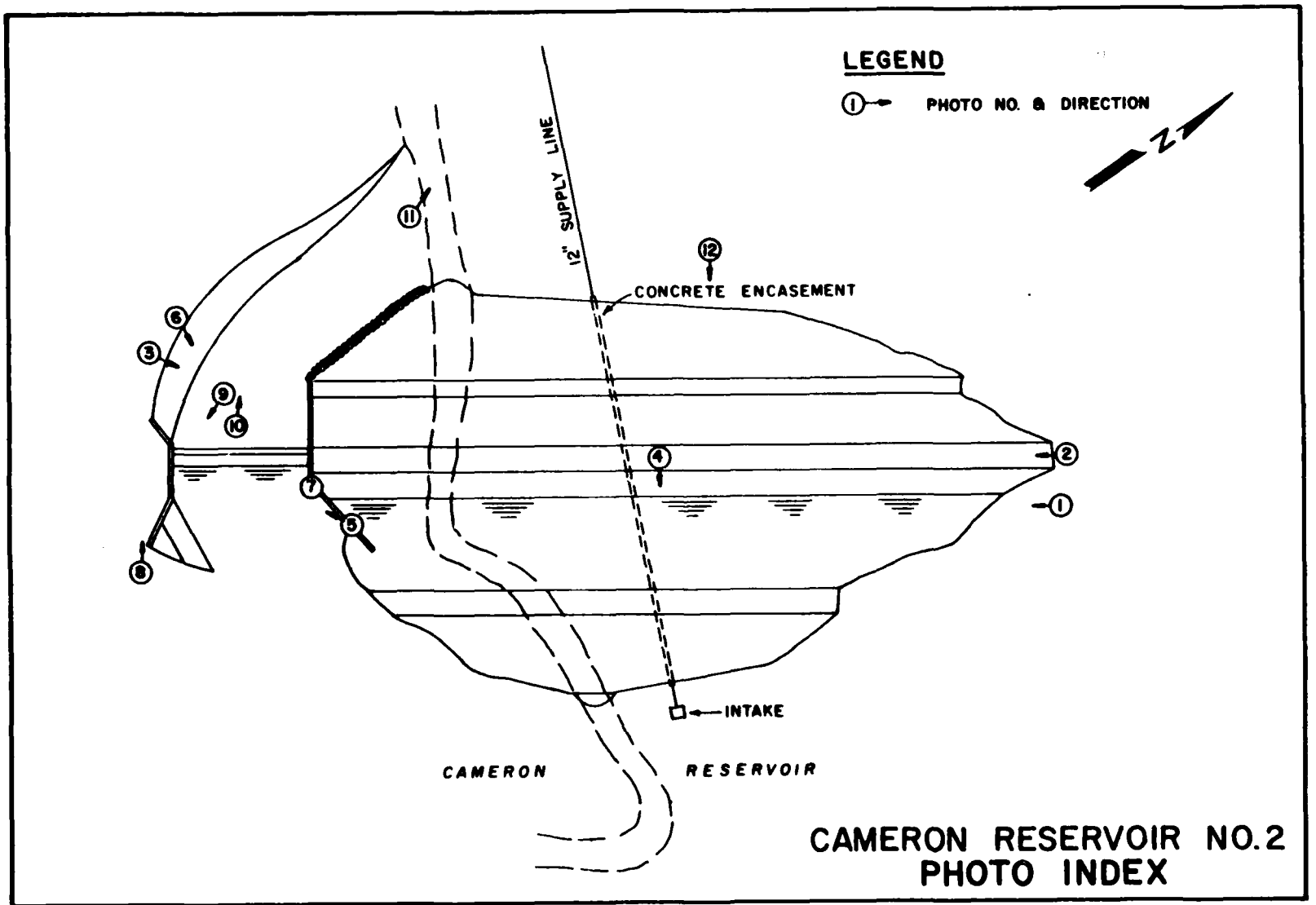
PLATE 5



SPILLWAY DRAINAGE SYSTEM NOT SHOWN.

CAMERON RESERVOIR NO. 2
SPILLWAY SECTION

PLATE 6



CAMERON RESERVOIR NO.2
PHOTO INDEX

PLATE 7

PHOTO 1: UPSTREAM FACE OF EMBANKMENT (FROM RIGHT ABUTMENT)

PHOTO 2: EMBANKMENT CREST (FROM RIGHT ABUTMENT)

PHOTO 3: DOWNSTREAM FACE OF EMBANKMENT AND PARTIAL VIEW OF SPILLWAY

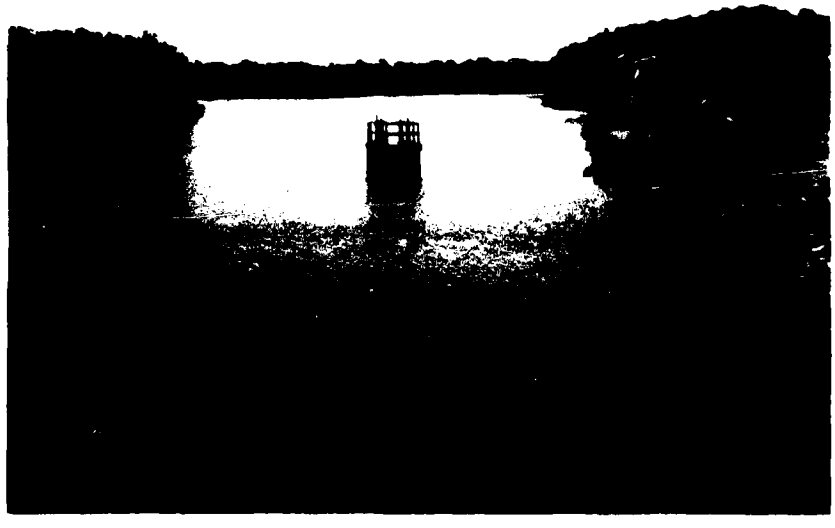


PHOTO 4: INTAKE STRUCTURE

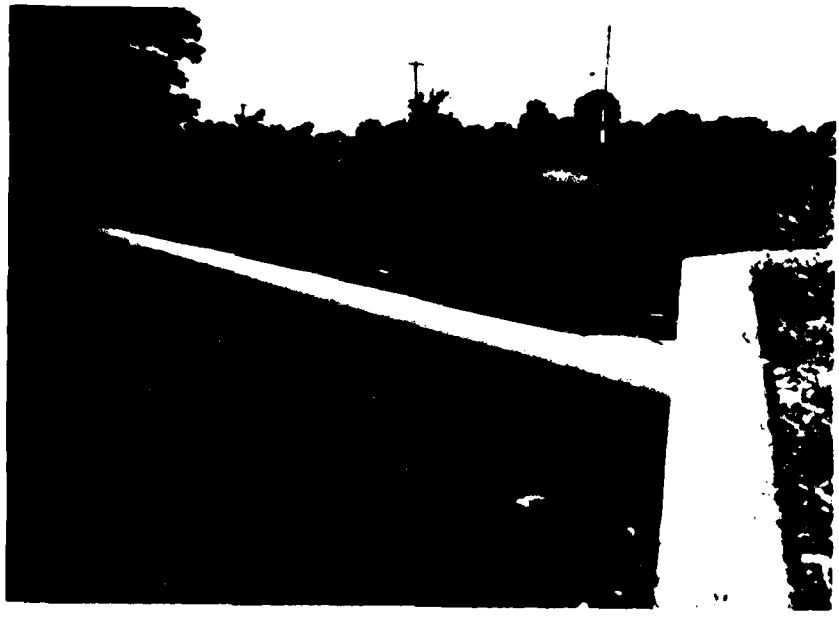


PHOTO 5: SPILLWAY CREST

PHOTO 6: SPILLWAY CREST AND DISCHARGE APRON
(LOOKING UPSTREAM)

PHOTO 7: SPALLING AND CRACKING OF RIGHT SPILLWAY RETAINING WALL

PHOTO 8: EROSION BEHIND LEFT SPILLWAY RETAINING WALL

PHOTO 9: SEEPAGE AT LEFT SPILLWAY ABUTMENT

PHOTO 10: SPILLWAY DISCHARGE APRON AND SPILLWAY UNDER DRAINAGE SYSTEM OUTLETS

PHOTO 11: POOL OF CAMERON RESERVOIR NO. 3 FROM TOE OF SPILLWAY DISCHARGE APRON

PHOTO 12: EROSION OF VEHICULAR PATH ON DOWNSTREAM FACE OF THE EMBANKMENT

APPENDIX A

HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1 (1) were used to develop the inflow hydrographs, and hydrologic inputs are as follows:

a. Forty-eight hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

200 square mile, 24 hour rainfall inches	- 24.5
10 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 101%
10 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 120%
10 square mile, 24 hour percent of 24 hour 200 square mile rainfall	- 130%
10 square mile, 48 hour percent of 24 hour 200 square mile rainfall	- 140%

b. Drainage area = 1,158 acres.

c. Time of concentration:

$Tc = (1.67)\ L$

$$L = \frac{\ell^{0.8}(S+1)^{0.7}}{1{,}900\ Y^{0.5}}$$

L = lag in hours

ℓ = hydraulic length of watershed in feet

$S = \frac{1{,}000}{CN'} - 10$ (where CN' is the retardance factor and is equivalent to the runoff curve number)

Y = average watershed land slope in percent

Tc = 1.20 hours (2).

d. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 94 and antecedent moisture condition III. The main soil associations in the watershed are Grundy, Lagonda, and Zook of the hydrologic soil group C. The land uses assumed

were pasture, crops, and some urbanized area. The hydrologic condition of the land was evaluated as poor.

2. Discharge rates through the spillway are based on the weir equation.

Weir equation:

$$Q = CLH^{1.5}$$ (C = varies from 2.48 to 3.32, L = 75 feet, H is the head on weir) (3).

Discharge rates over the top of the dam are based on the unlevel weir equation:

$$Q = \frac{2Cb}{5\,(h_b - h_a)}\,(h_b^{2.5} - h_a^{2.5})$$

(C = 2.63 = weir coefficient, b = the length of flow normal to the weir in feet, h_b = the head on the low end of the weir in feet, and h_a = the head on the high end of the weir in feet) (4).

3. The elevation-storage relationship above normal pool elevation was constructed by planimetering the area enclosed within each contour above normal pool. The storage between two elevations was computed utilizing the conic method for computation of reservoir volume provided in HEC-1 (1). The summation of these increments below a given elevation is the storage below that level.

(1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.

(2) U.S. Department of Agriculture, Soil Conservation Service, SCS National Engineering Handbook, Section 4, Hydrology, August, 1975.

(3) Horace W. King and Ernest F. Brater, Handbook of Hydraulics, Sixth Edition, McGraw Hill Book Company, 1976.

(4) U.S. Department of the Interior, Geological Survey, Techniques of Water Resources Investigation, Book 3, Chapter A5, Measurement of Peak Discharge at Dams by Indirect Methods, by Harry Hulsing, 1967.

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**********
FLOOD HYDROGRAPH    KAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
     1  A1MISSOURI DAM INSPECTION PROGRAM
     2  A2ST. LOUIS DISTRICT US ARMY CORPS OF ENGR
     3  A3CAMERON NO.2 LAKE NO. 10169
     4  B    288       0      10       0       0       0       0       0       0       0
     5  B1     5
     6  J      1       9       1
     7  J1   .10     .20     .25     .30     .35     .40     .45     .5      1.
     8  K      0       1                               3       1
     9  K1   48 HR PMF INFLOW
    10  M      1       2    1.81                       1
    11  P             24.5     101     120     130     140
    12  T                                                     -1     -94
    13  W2           .72
    14  X                      T
    15  K      1       2                                      1
    16  K1   ROUTE THROUGH SPILLWAY
    17  Y                                      1       1
    18  Y1     1                                              -942.8    -1
    19  Y4 942.8    943.    944.    945.    946.   946.5     947.    948.   949.950.
    20  Y4   951.
    21  Y5     0      17.    261.    690.   1335.   1729.   2155.   3135.  4658.7421.
    22  Y510965.
    23  $A     0      21.     30.     98.
    24  $E   915.    940.   942.2    960.
    25  $S 942.8
    26  $D 946.5
    27  K     99
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS								
				RATIO 1 .10	RATIO 2 .20	RATIO 3 .25	RATIO 4 .30	RATIO 5 .35	RATIO 6 .40	RATIO 7 .45	RATIO 8 .50	RATIO 9 1.00
HYDROGRAPH AT	1	1.81 (4.69)	1	1020. (28.88)	2040. (57.77)	2550. (72.21)	3060. (86.65)	3570. (101.09)	4080. (115.54)	4590. (129.98)	5100. (144.42)	10200. (288.84)
ROUTED TO	2	1.81 (4.69)	1	702. (19.89)	1557. (44.09)	1982. (56.12)	2423. (68.62)	2856. (80.88)	3330. (94.30)	3845. (108.87)	4328. (122.54)	9641. (272.99)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	942.80	942.80	946.50
STORAGE	249.	249.	387.
OUTFLOW	0.	0.	1729.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	945.02	0.00	327.	702.	0.00	40.83	0.00
.20	946.28	0.00	377.	1557.	0.00	40.83	0.00
.25	946.80	.30	399.	1982.	.83	40.67	0.00
.30	947.27	.77	421.	2423.	1.67	40.67	0.00
.35	947.72	1.22	441.	2850.	2.17	40.67	0.00
.40	948.13	1.63	461.	3330.	2.67	40.67	0.00
.45	948.47	1.97	477.	3845.	3.00	40.67	0.00
.50	948.78	2.28	493.	4328.	3.67	40.67	0.00
1.00	950.63	4.13	593.	9641.	6.17	40.50	0.00

END

DATE
FILMED

11-81

DTIC